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Socioeconomic Status and Executive Function in Early Childhood: Exploring Proximal Mechanisms

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Conflict of Interest

The authors have no known conflicts of interest to declare.

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Research Highlights

1. Lower parental education, but not income, predicted deficits in preschoolers' working memory/inhibitory control and self-control via higher maternal psychological distress.
2. A second indirect path, via greater psychological distress and increased harsh parenting, partially suppressed the overall effect of education on self-control.
3. Cognitive stimulation did not mediate relations between socioeconomic status and child executive function.

Abstract

Although there is substantial evidence that socioeconomic status (SES) predicts children's executive function, the mechanisms underlying this association are poorly understood. This study tested the utility of two theories proposed to link SES to children's executive function: the family stress model and the family investment model. Data came from the Midwestern Infant Development Study (*N* = 151). To measure SES, parental education and income were assessed during pregnancy, and income was also assessed when children were 6 and 36 months old. Children's executive function, operationalized as working memory/inhibitory control (WMIC) and self-control, was assessed at 36 months of age, along with potential mediators including maternal psychological distress, harsh parenting, and cognitive stimulation. Using structural equation modelling, we tested simultaneous pathways from SES to executive function: 1) via maternal psychological distress to harsh parenting (family stress model), and 2) via cognitive stimulation (family investment model). Of the SES measures, lower education predicted poorer WMIC directly and indirectly via greater maternal psychological distress. Lower education also predicted poorer self-control via greater maternal psychological distress; this effect was partially suppressed by an indirect path from lower education to better self-control via greater psychological distress and increased harsh parenting. Cognitive stimulation did not act as a mediator. Income was not directly or indirectly associated with EF. These findings provide partial support for the family stress model and are contrary to the predictions of the family investment model, suggesting that SES' impact on family functioning is particularly important for the development of children's executive function.

Keywords: executive function, socioeconomic status, family stress, family investment

Socioeconomic Status and Executive Function in Early Childhood: Exploring Proximal Mechanisms

The impact of socioeconomic status (SES) on cognitive and socio-emotional development is well established. Children raised in economically disadvantaged households lag behind their more privileged peers on measures of intelligence, emotion regulation, and academic performance (Bradley & Corwyn, 2002). Executive function (EF) refers to the set of higher-order cognitive processes that support goal-directed behaviour (Zelazo & Muller, 2012). EF has been identified as a primary cognitive system impacted by social inequalities in early experience (Lipina & Posner, 2012). Research on SES and cognitive outcomes indicates that there is a particularly strong association between early adversity and EF (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005; Sturge-Apple et al., 2016). Although SES is a robust predictor of developmental outcomes, its effect on child development must be mediated by more proximal characteristics of the child's environment (Bronfenbrenner, 1979). The goal of the present study is to examine specific psychosocial and environmental factors through which SES exerts its effect on EF. This goal is important for both basic scientific understanding and for specifying practical targets for early intervention.

EF in Early Childhood

EF begins to emerge in the first year of life (Diamond & Goldman-Rakic, 1989), and individual differences in EF show moderate stability by early childhood (Carlson, Mandell, & Williams, 2004). Early childhood is a period of substantial, rapid development in EF (Clark et al., 2013; Wiebe, Sheffield, & Espy, 2012). EF during this timeframe predicts proximal and distal developmental outcomes like social competence in early childhood (K. A. Blair, Denham, Kochanoff, & Whipple, 2004), and SAT scores in early adulthood (Mischel, Shoda, & Rodriguez, 1989).

One recent model of EF conceptualizes it as two interrelated but distinct constructs that differ in the contexts in which they are used (Wiebe et al., 2015; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011; Zelazo & Muller, 2012). One dimension operates in contexts that tax children's EF due to cognitive load; for example, holding information in mind or overcoming an automatic response (Zelazo & Muller, 2012). In early childhood, this dimension typically corresponds to the constructs of working memory (the ability to hold in mind and manipulate information) and inhibitory control (the ability to inhibit an automatic response), referred to collectively as WMIC (see Wolfe & Bell, 2004, 2007). Factor analytic studies of WMIC have found that a single-latent factor model accounts for these two cognitive processes as well as more complex, multi-factor models in 2- to 6-year-olds (Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011; Willoughby, Blair, Wirth, & Greenberg, 2010, 2012; Willoughby et al., 2011). There is also empirical support for a second dimension of EF that is taxed primarily in contexts high in motivational load relative to cognitive load (e.g., regulating responses to a reward or distressing situations; delaying consumption of a tempting treat), termed self-control (Wiebe et al., 2015; Willoughby et al., 2011; but see Allan & Lonigan, 2011 for an exception). The distinction between WMIC and self-control appears to correspond to a neuroanatomical division of labor where WMIC involves dorsolateral prefrontal cortex and self-control involves orbitofrontal cortex (Zelazo & Muller, 2012). Further, WMIC and self-control are differentially associated with developmental outcomes: WMIC is uniquely predictive of cognitive outcomes like academic performance, while self-control is associated with behaviour problems in children (Willoughby et al., 2011).

SES and EF Development: Potential Mediators

SES is associated with individual differences in children's EF (Noble et al., 2007, 2005; Sturge-Apple et al., 2016). In particular, SES is predictive of WMIC both concurrently and longitudinally in early childhood (for a recent meta-analysis see Lawson, Hook, & Farah, 2018). For example, children raised in lower SES households have poorer WMIC at 36 months of age (C. Blair et al., 2011). Similarly, children raised in middle and high SES households outperform children raised in lower SES households on self-control tasks at 36 months (Bernier et al., 2012; Sturge-Apple et al., 2016).

From a bioecological perspective (Bronfenbrenner, 1979), SES is conceptualized as a more distal contextual factor associated with child outcomes via its influence on proximal psychosocial and environmental factors that are more directly linked to children's cognitive and psychosocial development. Thus, a full understanding of the relation between SES and children's EF necessitates investigation of the mechanisms driving this association. The present study tests the utility of two theoretical models, proposed to explain the impact of SES on child outcomes, in accounting for the SES-EF relation: the family stress model (Conger & Conger, 2002) and the family investment model (Haveman & Wolfe, 1994).

The family stress model (Conger & Conger, 2002) emphasizes the negative effect of parental stress on parent-child relationships and child development in economically disadvantaged households. In this model, parents in lower SES households experience more financial and social stressors, which lead to increased psychological distress. Psychological distress, in turn, affects parents' interactions with their children, including increased detachment, irritability, and harsh and inconsistent discipline (Conger & Donnellan, 2007), which predict poorer cognitive (e.g., academic performance) and socio-emotional outcomes (e.g., development of behaviour problems) in children. While the full pathway from SES to EF via the effect of psychological distress on parental behaviour has yet to be examined, there is support for some of the links within this pathway. Maternal depression and psychological distress have been linked to poorer WMIC and emotion regulation, a construct closely related to self-control, in 2- to 4-year-old children (Hoffman, Crnic, & Baker, 2006; Hughes, Roman, Hart, & Ensor, 2013). However, studies examining maternal psychological distress as a mediator of the association between SES and EF did not find an association (Hackman, Gallop, Evans, & Farah, 2015; Li-Grining, 2007; Rhoades, Greenberg, Lanza, & Blair, 2011). There is some support for harsh parenting (e.g., detachment, intrusiveness, and negative affect) as a mediator of the SES-EF relation, such that lower SES is associated with increased harsh parenting, which in turn predicts poorer EF, measured as a composite including WMIC and set-shifting, in preschoolers (C. Blair et al., 2011; Rhoades et al., 2011). Whether these findings extend to self-control has not been tested.

The family investment model (Conger & Donnellan, 2007) posits that cognitive stimulation in the home environment is a critical factor for children's neurocognitive development. In this model, parents in lower SES households have fewer resources to invest in providing children with cognitively stimulating learning materials and experiences that promote their cognitive development (e.g., access to books or museum visits). Consistent with this model, reduced access to learning materials and literacy activities mediates the effect of SES on WMIC and planning, but not set shifting, in children ages 3 through 12 (Clark, James, & Espy, 2016; Hackman et al., 2015; S. Lipina et al., 2013; Noble et al., 2007; see Sarsour et al., 2011 for an exception). Additionally, access to learning materials buffers the negative effect of SES on children's EF at 36 months of age (Nelson et al., 2015). Further, parental investment in learning materials is not associated with the development of behaviour problems in children raised in economically disadvantaged households (Kim-Cohen, Moffitt, Caspi, & Taylor, 2004; Yeung, Linver, & Brooks-Gunn, 2002), suggesting that parental investment may be particularly important for the development of WMIC and less important for the development of self-control.

The Present Study

The aim of this study was to test the utility of two key theoretical models (family stress and family investment) in elucidating the mechanisms linking SES to children's EF in a predominantly low SES cohort (see Figure 1 for conceptual model). To test the family stress model, we examined the indirect effect of SES on EF via maternal psychological distress, independently and through its link to harsh parenting. To test the family investment model, we examined the indirect effect of SES on EF via cognitive stimulation. We used data from three waves of the Midwestern Infant Development Study (MIDS), a cohort prospectively recruited during pregnancy, to achieve this aim.

The key strength of this study was the inclusion of multiple potential candidate mediators, allowing us to test both theoretical models simultaneously. Many previous studies have focused either on parenting or quality of the home environment as potential mediators of the SES-EF relation, providing some support for the family stress and family investment models (e.g., Blair et al., 2011; Sarsour et al., 2011; see Hackman et al., 2015 for an exception). SES affects a multitude of intercorrelated factors likely to affect the development of EF (Bradley & Corwyn, 2002). When each potential mediator is examined in isolation, one cannot eliminate the possibility that excluded correlated factors might contribute to observed pathways. The inclusion of multiple potential candidate mediators strengthens support for any observed pathways helping to mitigate the possibility that excluded factors might be contributing to the relation.

Methods

Study Design and Participants

Data for the present study was drawn from 3 waves of the Midwestern Infant Development Study (MIDS), collected during pregnancy (28 weeks gestational age), and when children were 6 and 36 months old. MIDS is a predominantly low SES cohort (sample SES and demographic information is presented in Table 1) prospectively recruited to study the effects of prenatal tobacco exposure on cognitive development (Espy et al., 2011; Wiebe et al., 2015; Wiebe, Fang, Johnson, James, & Espy, 2014). Mothers were recruited during pregnancy at two Midwestern study sites (Carbondale, Illinois, and Lincoln, Nebraska) and provided written, informed consent prior to their participation in the study. Mothers who reported binge drinking or illegal drug use, with the exception of occasional marijuana use, were excluded from the MIDS cohort, as were infants born preterm (< 35 weeks gestational age) or with birth complications known to affect developmental outcomes (e.g., neonatal seizures). The full MIDS cohort includes 304 mother-child dyads.

The sample in the present analysis included 151 mother-child dyads (children: 79 boys, 85 exposed to prenatal tobacco, M_{age}= 3 years 7 days, *SD* = 22 days), from the Nebraska site, where the child had usable EF data at 36 months of age and data were available on key covariates (sex and prenatal tobacco exposure status). Children at the Illinois site could not be included because they were not assessed at 36 months due to funding constraints. Dyads included in the final sample did not differ significantly from excluded dyads in terms of prenatal tobacco exposure status, maternal education, ethnicity, or child sex.

Procedure

During each wave of data collection, mothers completed background interviews that included questions about household SES. When children were 36 months old, mother-child dyads visited a developmental laboratory at the University of Nebraska for three sessions separated by approximately one week. Children completed an EF battery administered in a fixed order to ensure that potential carry-over effects across tasks would be consistent for all participants. Adherence to experimental protocols was maintained by regular team meetings and reviews of session video recordings. Between the sessions, mothers completed a telephone interview and questionnaires assessing psychological distress, parenting, and cognitive stimulation. Children received a small toy at each session, and mothers received a gift card after all three sessions were complete. Tasks and scales selected for the present analyses are described below. Study procedures were approved by the University of Nebraska-Lincoln's Institutional Review Board.

Measures

SES. Two measures of household SES were created using information provided in the background interviews at the pregnancy, 6-month, and 36-month waves. Income-to-needs ratio was calculated by dividing mother-reported family income by the federal poverty threshold adjusted for family size (McLoyd, 1998) at all three time points. A composite measure of income-to-needs ratio was created by averaging income-to-needs ratio over all three waves. Correlations across income-to-needs ratios over the three waves ranged from .66 - .73 (*p*s < .01). Mothers reported on each parent or caregiver's highest degree at each time point. For two-parent households, the highest level of education was used as the measure of parental education. For single-parent households, the mother's highest degree was used. Because education was highly correlated across waves (r = .76 - .84), only parental education at pregnancy was used in the analysis.

Potential mediators: maternal psychological distress. When children were 36 months old, mothers completed the Brief Symptom Inventory (BSI; Derogatis, 1993), a 53-item self-report measure assessing psychological distress along nine dimensions: somatization, obsessive-compulsive behavior, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. Statements such as "How much were you distressed by nervousness or shakiness?" were rated on a 5-point Likert-type scale ranging from "0 = Not at all" to "4 = Extremely." Scores on each item were summed and divided by the number of questions answered to create the Global Severity Index, which was used as our measure of psychological distress. Internal consistency for the Global Severity Index was excellent (α = .97) and it demonstrates convergent validity with the Minnesota Multiphasic Personality Inventory (Derogatis & Melisaratos, 1983).

Potential mediators: harsh parenting. Mothers completed the Parenting Styles and Dimensions Questionnaire (PSDQ; Robinson, Mandleco, Olsen, & Hart, 1995), a 62 item self-report assessment examining parental warmth, positive parenting strategies, and disciplinary practices, when children were 36-months old. Items such as "I explode in anger towards our child" were rated on a 5-point scale ranging from "1 = Never" to "5 = Always." A harsh parenting score was created by dividing the summed score of the verbal hostility, corporal punishment, non-reasoning/punitive strategies, and directness subscales by the number of questions answered. Internal consistency was good (α = .82). The subscales making up the harsh parenting scoring are correlated with observational ratings of parent–child interactions (Robinson et al., 1995).

Potential mediators: cognitive stimulation. Three subscales of the Early Childhood Home Observation for Measurement of the Environment Scale (EC-HOME; Caldwell &

Bradley, 1984) were used to assess cognitive stimulation at 36 months. The EC-HOME is normally administered via home observation and semi-structured interview. The adapted measure consisted of the learning materials (e.g., “child has 3 or more puzzles”), language stimulation (e.g., “parent encourages child to talk and takes time to listen”), and academic stimulation (e.g., “child is encouraged to learn numbers”) subscales. All items of these subscales can be administered via semi-structured interview. Research assistants administered the measure as a phone interview and rated whether the criteria for each question was met (0 = No, 1 = Yes). Scores for the three subscales were tallied and the weighted average of their sums was used to index cognitive stimulation. Internal consistency for the measure of cognitive stimulation was adequate (KR-20 = .71). The learning materials, language stimulation, and academic stimulation subscales had adequate internal consistency (KR-20 = .65-.88) and demonstrate concurrent and predictive validity with measures of household SES and children’s IQ (Caldwell & Bradley, 1984). Further, a telephone interview version of the middle childhood HOME Scale demonstrates convergent validity with the original scale (Lai, O’Mahony, & Mulligan, 2015).

EF. A battery of seven EF tasks (Wiebe et al., 2015) was administered when children were 36 months old. Factor analysis supported a two-factor measurement model for EF, reported elsewhere (Wiebe et al., 2015). Briefly, a two-factor (WMIC and self-control) model fit the data well, $\chi^2(19) = 28.06$, $p = .08$, $RMSEA = .06$, $CFI = .96$, $SRMR = .05$, provided a better model fit better than a one-factor model ($\Delta\chi^2(1) = 36.07$, $p < .05$), and was more parsimonious than a three factor (WM, IC, and self-control) model ($\Delta\chi^2(2) = 2.07$, $p = .36$). Five tasks loaded on a WMIC factor, including *Delayed Alternation, Nebraska Barnyard, Big-Little Stroop, Preschool Go/No-Go,* and *Shape School-Inhibit Condition.* Two tasks loaded on a self-control factor (*Goody Shelf* and *Snack Delay*). Descriptions of each task are in Table 2. Administration, psychometric properties, scoring, and validation of the EF battery and measurement model are described in more detail elsewhere (Wiebe et al., 2015, 2011).

Covariates. Because sex differences in EF are sometimes reported (e.g., Carlson & Wang, 2007), child sex was included as a covariate. Additionally, because the MIDS cohort was recruited to examine the effects of smoking during pregnancy, prenatal tobacco exposure was included as a covariate. Mothers completed timeline-follow-back interviews about daily smoking at two points during pregnancy and shortly after their child's birth, with exposure status verified by assaying maternal urine and infant meconium for cotinine, a metabolite of nicotine (Espy et al., 2011).

Analytic Strategy

Univariate distributions for all variables were examined for non-normality and outliers. Only maternal psychological distress was not normally distributed. Outliers were trimmed to two standard deviations from the mean. In total, 5% of the data were missing, ranging from < 1% (maternal psychological distress) to 34% (*Shape School*); see Tables 1 and 3 for more details. Missing data were dealt with using full information maximum likelihood estimation (FIML) with an expectation maximization algorithm. Because FIML assumes that data are missing at random, a series of logistic regression models were computed to test whether missingness on outcome measures was related to demographic characteristics. Missingness was unrelated to SES, prospective mediators, EF, prenatal tobacco exposure status, maternal education, child ethnicity, or child sex (*p*s > .05).

Structural equation modeling (SEM) was conducted using MPlus 7.3 (Muthén & Muthén, 2012). Model fit was assessed using the chi-square (χ^2) statistic, root mean square error of approximation (*RMSEA*), comparative fit index (*CFI*), and standardized root mean square residual (*SRMR*). Values indicating good fit were less than .06 for the RMSEA, .95 – 1.00 for the CFI, and less than .08 for the SRMR (Hu & Bentler, 1999). Values indicating adequate model fit were .90 – .94 for the CFI, a RMSEA of .06 – .08, and less than .10 SRMR (Hu & Bentler, 1999; Kline, 2015). The chi-square difference ($\Delta\chi^2$) test was used to compare nested models (Kline, 2015). When the test was significant ($p < .05$), the less constrained model was retained; otherwise, the more parsimonious model was favored.

Two-step structural regression was used to examine whether SES predicted EF in children. In Step 1 of the analysis, confirmatory factor analysis (CFA) was used to develop the latent construct of EF (Kline, 2015). In Step 2, the predicted structural regression model was tested by adding directional paths between SES and EF within the best-fitting model from Step 1 (Kline, 2015). Covariates were then added to this model to examine the impact of their inclusion on SES-EF paths.

Multiple mediation was used to test candidate mediators. First, all mediators were added to the final model from the structural regression, guided by the conceptual model in Figure 1. Next, individual non-significant paths were trimmed sequentially beginning with the least significant path, and the residual variance-covariance matrix was examined to identify paths that needed to be added to the model (see Kline, 2015; Little, 2013). Model comparison statistics were used to determine the most parsimonious model that still fit the data. Once the final model was established, mediation was tested by calculating indirect effects with bias-corrected bootstrapped 95% confidence intervals. Indirect paths were deemed statistically significant if the confidence interval for the effect did not include zero (Fairchild & McQuillin, 2010). This approach is preferred over the traditional Causal Steps approach (Baron & Kenny, 1986) because it better accounts for the non-normal distribution of the indirect effects and therefore has higher statistical power, such that indirect effects may reach significance even when the overall main effect does not (Fairchild & McQuillin, 2010; MacKinnon & Fairchild, 2009).

Results

Descriptive Statistics

Descriptive statistics for the main variables used in the analyses are presented in Table 3, and correlations among these variables and latent variables are presented in Table 4. The measures of SES were moderately correlated. In general, SES measures and potential mediators were moderately correlated, with the exception of harsh parenting which was uncorrelated with SES measures. Most correlations between parental education and WMIC indicators were small to moderate. The remaining SES measures and EF indicators were not significantly correlated. Correlations among the indicators of WMIC were typically significant but small to moderate in magnitude, whereas indicators of self-control were moderately to strongly correlated. Most indicators of WMIC and self-control were not significantly correlated, although latent WMIC and self-control were moderately correlated. Education was moderately correlated with latent WMIC. All other correlations between measures of SES and latent EF were not significant. Correlations between the potential mediators and latent EF were generally significant and small to moderate in magnitude.

Structural Regression

A structural regression model tested paths from income-to-needs and parental education to WMIC and self-control (see Figure 2). Prenatal tobacco exposure status and child sex were included as covariates. Education predicted WMIC (b = .25, SE = .08, p < .01, R^2 = .37), such that as parent's education increased, so did children's WMIC. Income-to-needs was not associated with WMIC (b = .01, SE = .15, p = .95). Neither education (b = -.02, SE = .06, p =

.74) nor income-to-needs predicted self-control (*b* = .14, *SE* = .12, *p* = .25). Prenatal tobacco exposure was associated with poorer self-control (*b* = -.66, *SE* = .20, *p* < .01) but not WMIC (*b* = -.08, *SE* = .23, *p* = .73). Sex was not associated with either WMIC (*b* = .23, *SE* = .23, *p* = .33) or self-control (*b* = -.33, *SE* = .19, *p* = .08). This model showed good fit to the data, $\chi^2(43) = 51.40$, *p* = .18, *RMSEA* = .04, *CFI* = .96, *SRMR* = .06.

Multiple Mediation Model

Next, we tested a multiple mediation model examining if maternal psychological distress, harsh parenting, and cognitive stimulation mediated the relations between SES and children's EF, controlling for prenatal tobacco exposure status and child sex. First, guided by the conceptual model in Figure 1, potential mediators were added to the final model from the structural regression analysis. Then, non-significant paths were trimmed sequentially. In addition, the standardized residual correlation matrix was examined for residuals with absolute values greater than 2.0, which indicate that the model does not explain the corresponding sample correlation well (Kline, 2015). This process resulted in changes to several key paths predicted by the family investment and family stress models. The paths from cognitive stimulation to WMIC and self-control were not retained, nor was the path from harsh parenting to WMIC. The final multiple mediation model is presented in Figure 3 and indirect effects are reported in Table 5. Model fit to the data was good, $\chi^2(68) = 71.18$, *p* = .37, *RMSEA* = .02, *CFI* = .99, *SRMR* = .06. For WMIC, the path from maternal psychological distress was retained in the final model. There was a significant indirect pathway from parental education to WMIC via psychological distress. Maternal psychological distress explained 15% of the total effect of education on WMIC. Children raised in households with lower parental education had mothers who experienced more psychological distress, which predicted poorer WMIC. The direct effect of education on WMIC was significant after accounting for psychological distress. Income-to-needs did not significantly predict WMIC directly or indirectly via psychological distress. The effects of prenatal tobacco exposure (*b* = -.07, *SE* = .24, *p* = .77) and sex (*b* = .24, *SE* = .23, *p* = .32) were non-significant.

For self-control, the paths from maternal psychological distress and harsh parenting were retained in the final model. Although the overall effect of education on self-control was not significant, there was a significant indirect effect via maternal psychological distress when controlling for covariates and other mediators. Paralleling findings for WMIC, children raised in households with lower parental education had mothers who experienced more psychological distress, which predicted poorer self-control. There was also a significant indirect effect of education on self-control in the opposite direction, via the effect of maternal psychological distress on harsh parenting. Greater maternal psychological distress was related to harsher parenting, which predicted better self-control. This pathway acted as a suppressor, reducing the total indirect effect of education via maternal distress by 21%. Suppression occurs when the inclusion of a control variable decreases the magnitude of an independent variable's effect on the dependent variable and is indicated when the effects have opposite signs (MacKinnon, Krull, & Lockwood, 2000). The direct effect of parental education on self-control was non-significant after accounting for mediators. The indirect pathways from income-to-needs to self-control via psychological distress, both independently and via harsh parenting, were non-significant. Of the covariates, prenatal tobacco exposure was associated with poorer self-control (*b* = -.74, *SE* = .20, *p* < .01), while sex was not associated with self-control (*b* = -.34, *SE* = .19, *p* = .07).

Discussion

This study provides new insight on the specific factors contributing to the development of EF in children raised in economically disadvantaged households. We tested indirect pathways based on two models, family stress and family investment, to explain the relations between SES and two aspects of children's EF: WMIC and self-control. We found support for direct and indirect effects of parental education, but not income-to-needs ratio, on WMIC, and for indirect effects on self-control. Lower education predicted poorer WMIC directly and indirectly via greater maternal psychological distress. Lower education also predicted poorer self-control via greater maternal psychological distress. However, a second indirect path from lower education to better self-control, via greater maternal distress and increased harsh parenting, partially suppressed this indirect effect. These findings provide partial support for the family stress model and suggest that additional factors, unmeasured in the present study, contribute to the association between education and WMIC. No significant indirect pathways involved cognitive stimulation, contrary to the predictions of the family investment model.

One interesting finding was that parental education, but not income-to-needs, was related to children's EF. This result is consistent with work suggesting that the effect of SES on children's EF and PFC development is driven primarily by parental education (C. Blair et al., 2011; Lawson, Duda, Avants, Wu, & Farah, 2013; Noble et al., 2005). It also supports suggestions that parental education is the single most predictive aspect of SES for child development more broadly (Bornstein, Hahn, Suwalsky, & Haynes, 2003; Noble et al., 2005). Why education and income might be differentially related to EF is unclear. They may be associated with different proximal environmental factors. For example, education has been argued to reflect more stable characteristics of the parent that influence the parent-child relationship, such as scaffolding (Duncan & Magnuson, 2012), whereas income may contribute to children's exposure to environmental stressors such as overcrowding or lead exposure (McLoyd, 1998). Our differential findings for income-to-needs and parental education underscore the importance of examining the unique effects of specific SES indicators on children's EF.

There was partial support for the family stress model for WMIC and self-control, as parental education had a significant indirect effect via maternal psychological distress on both outcomes, both independently and via harsh parenting for self-control. However, contrary to the predictions of this model, the effects of education on poorer WMIC and self-control via greater psychological distress were largely independent of parenting. It is likely that there are alternative pathways, unmeasured in the present study, that explain the relation between maternal psychological distress and children's EF. Psychological distress is associated with changes in parental behaviour that are not always well reflected in parent report measures, such as indifferent or unresponsive parenting, as well as changes in the home environment, such as increased marital conflict and lack of extra-familial social support, which predict behaviour problems and emotion dysregulation in children, constructs characterized by deficits in EF (Cummings & Davies, 1994). Further, education continued to be associated with WMIC, even after accounting for the effect of psychological distress. Additional factors, unmeasured in the present study, are known to contribute to the association between SES and WMIC, including household chaos, housing quality, and child care quality (Clark et al., 2016; Noble et al., 2007). It is likely that alternative pathways, not captured by the family stress model, contribute to SES-related disparities in WMIC.

Based on the family stress model, we predicted that lower SES would be associated with poorer EF via the effect of increased maternal psychological distress on increased harsh parenting. While the indirect path from education to self-control was significant, its direction ran counter to the family stress model as harsher parenting predicted better self-control. One possible explanation for this finding may relate to the task demands of our self-control measures: increased immediate compliance with the experimenter's directives would improve children's performance. There is evidence that children who experience harsh parenting are more likely to comply with directives to avoid punishment (Gershoff, 2002; Talwar, Carlson, & Lee, 2011). This finding may also relate to the socio-cultural context in which children in the sample are raised. Our sample was ethnically diverse (48% non-Caucasian). Among low SES African-American families, parenting that is high in control or physical discipline and high in warmth is a protective factor for developmental outcomes like self-regulation (Brody & Flor, 1998). Similarly, research on cultural differences in parenting styles suggests Latinx parents are high in warmth and control and low in granting autonomy (Rodriguez, Donovick, & Crowley, 2009). They also hold higher expectations for compliance than African American or European American parents (Dearing, 2004). Consequently, the impact of harsh parenting may differ depending on a child's socio-cultural context. We did not have a large enough sample to run separate models for each ethnic group, but this is an important question for future research. Finally, it is important to recall that the magnitude of the effect of harsh parenting was relatively small (b = -.01; see Table 5), and that parents' psychological distress accounted for the majority of the effect of education on self-control (b = .05). Further, the overall relations between education, parental distress, and self-control were consistent with the predictions of the family stress model.

Cognitive stimulation did not mediate the relations between SES and EF. This finding runs counter to the family investment model and previous work demonstrating an indirect effect of SES on WMIC via cognitive stimulation (Clark et al., 2016; Hackman et al., 2015; Lipina et al., 2013). Our study may have failed to replicate this effect because of differences in the measurement of cognitive stimulation. Lipina et al. (2013) focused on the frequency of literacy activities. Clark et al. (2016) and Hackman et al. (2015) used different EC-HOME subscales from those assessed in the present study. This leaves open the possibility that aspects of the home environment, unmeasured in the present study, might contribute to children's EF development.

Findings from the current study should be interpreted in light of the study's strengths and limitations. In addition to the inclusion of multiple candidate mediators, this study also benefited from the use of a latent variable approach to measuring EF, improving construct reliability and combating the task impurity problem. Individual EF tasks are often unreliable measures of EF because performance reflects variations in both EF abilities and the basic abilities required to complete the tasks (e.g., motor abilities), known as the task impurity problem (Miyake et al., 2000). The use of a latent variable approach resulted in a model with good fit to the data, separating EF contributors to task performance from extraneous task-specific contributors, likely improving our ability to detect relations between measures of SES, candidate mediators, and EF.

Alongside these strengths, the present study has a number of limitations. First, and most importantly, while SES was assessed at earlier time points, candidate mediators were measured concurrent with EF, making it impossible to establish the direction of the relations between potential mediators and children's EF. As children's characteristics influence caregiver behaviour (Bell, 1968), child EF may, in fact, predict the potential mediators considered in this study, or relations may be transactional. For example, the association between sensitive and responsive parenting and children's EF is transactional between 36 and 60 months of age (C. Blair, Raver, Berry, & Family Life Project Investigators, 2014). Second, this study did not systematically assess language spoken at home. Twenty percent of children were Hispanic or

Latinx so it is likely that some children were bilingual. This may have affected our results, as some studies have found that bilingualism is related to child EF (Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012; Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011; although see Paap, Johnson, & Sawi, 2015 for conflicting results). Third, we used a self-report measure of parenting instead of an observational measure. Mothers' reports of their own behaviour may be biased and parents' characteristics influence their reporting of their behaviour (Karreman, van Tuijl, van Aken, & Dekovic, 2008). Observational measures of parenting would allow for a more unbiased and objective examination of the effects of parenting on children's EF. Fourth, the present study lacked sufficient statistical power to test interactions among potential candidate mediators. There is evidence that cognitive stimulation in the home environment impacts maternal psychological well-being and behaviour (Yeung et al., 2002), so one might predict interactions between factors emphasized by the family stress and family investment models.

SES is a multidimensional construct that encompasses many aspects of children's environments and likely influences their developing EF skills in multiple ways. Parental education, but not income-to-needs ratio, was associated with children's EF, both directly for WMIC and indirectly via maternal psychological distress for WMIC and self-control. Therefore, it is important to consider how individual components of SES independently impact EF development. Furthermore, EF deficits in early childhood are of particular concern because EF is an important predictor of later academic and psychosocial outcomes (K. A. Blair et al., 2004; Mischel et al., 1989). Based on the present study's findings, support for parents' psychological well-being is a reasonable candidate for interventions to improve EF in at-risk children in the early years.

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Table 1

Sample demographic information

Construct	N	M	SD	Range
Child sex (% female)	151	48%		
Prenatal tobacco exposure status (% exposed)	151	56%		
Child ethnicity	151			
European-American		52%		
African-American		24%		
Hispanic or Latinx		20%		
Native American		1.3%		
Multiracial		3.3%		
Marital status (36 months)	149			
Single, never married/cohabitating		23.%		
Married/cohabitating		65%		
Divorced/no longer cohabitating		12%		
Mother working (36 months; % working)	150	65%		
Child in care outside of home (≥ 20 hrs/week; 36 months)	141	40%		
Income-to-needs ratio (composite score)	151	1.31	0.80	0.00 – 4.32
< 0.50		11%		
< 1.00		30%		
< 1.50		25%		
< 2.00		19%		
≥ 2.00		15%		
Parental education (years)	151	13.31	1.63	11.00 – 20.00
Less than a highest school diploma		9%		
High school diploma or GED		38%		
Associate degree		36%		
Some college		9%		
Bachelor's degree		7%		
Graduate degree (Master's, PhD, JD, or MD)		2%		

Table 2

Executive function task descriptions

Task	Description	Dependent Measure
	Working Memory/Inhibitory Control	
Delayed Alternation	Children searched for a hidden food reward in one of two locations; the examiner hid the reward out of the child's view, changing the location after each correct response	Proportion of correct responses
Nebraska Barnyard	Children listened to sequences of animal names then pressed colored buttons corresponding to the names in order on a touch screen	Summary score calculated by summing the proportion of correct trials at each span length
Big-Little Stroop	Children named small pictures of everyday objects, embedded within larger pictures that matched (congruent trials) or mismatched (incongruent trials) the small pictures	Proportion of correct responses on incongruent trials
Preschool Go/No-Go	Children pressed a button on a button box to catch fish (75% of trials), but not sharks (25% of trials)	*d'* (d-prime; the standardized difference between the hit rate and false alarm rate)
Shape School Inhibit Condition	Children named the color of a cartoon shape character when the character had a happy face, but remained silent when it had a sad face (inhibit trials)	Proportion of correct responses on inhibit trials
	Self-control	
Goody Shelf	Children were instructed that they could look at, but not touch, a shelf containing appealing toys over a 5-minute delay	Summary score representing child noncompliance: Each instance of toy touching was scored between 1 (brief touches) and 3 (sustained touches where the child was resistant to examiner prompts)

Snack Delay	Children were instructed to keep their hands on a placemat marked with two handprints and stand still in front of M&M candies placed under a transparent cup during a 4–minute delay	1. Summary score representing child compliance in 5-second intervals until either the child ate the snack or the task ended: Children received up to 3 points for standing still, keeping their hands on the mat, and remaining silent 2. Task success: whether the child ate the snack during the delay period

Table 3

Descriptive statistics for the prospective mediators and executive function indicators

Construct	N	M	SD	Range
Psychological distress (composite score)	150	0.46	0.40	0.00 – 1.52
Harsh parenting (composite score)	151	1.89	0.38	1.15 – 3.30
Cognitive stimulation (weighted average)	148	0.79	0.13	0.35 – 1.00
Delayed Alternation (accuracy)	145	0.50	0.18	0.00 – 0.94
Nebraska Barnyard (composite score)	139	3.31	1.74	0.58 – 8.06
Big-Little Stroop (conflict trial accuracy)	138	0.25	0.25	0.00 – 1.00
Go/No-go (d')	145	0.53	0.98	-1.37 – 3.12
Shape School inhibit (accuracy)	100	0.36	0.26	0.00 – 1.00
Goody Shelf (rule-breaking)	143	3.64	7.27	0.00 – 33.00
Snack Delay (movement score)	139	50.62	32.04	3.00 – 117.00
Snack Delay (ate treat)	139	0.33	0.47	0.00 – 1.00

Table 4

Correlations between measures of SES and executive function, mediator, covariates, and latent executive function factors

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Income-to-needs	--	.27**	-.04	.07	.30**	.22**	.12	.02	.11	-.01	.13	-.04	.04	-.01	.06
2. Parental education		--	-.23**	-.04	.26**	.08	-.16*	.23**	.32**	-.02	.19*	.11	.10	.01	.09
3. Psychological distress			--	.31**	-.15+	-.04	.06	-.23**	-.19*	-.07	-.13	-.12	-.18*	-.22**	-.17*
4. Harsh parenting				--	-.14+	.03	.14+	.00	-.07	-.04	-.05	-.01	-.16+	.08	.08
5. Cognitive stimulation					--	-.10	-.10	.06	.12	.05	.17*	.11	.11	.10	.13
6. Child sex						--	-.07	.05	.06	.09	.10	.07	-.13	-.11	-.04
7. Prenatal tobacco exposure							--	.02	-.07	-.11	.01	-.12	-.18*	-.25**	-.23**
8. Delayed Alternation								--	.30**	.25**	.19*	.14	.15+	.14	.07
9. Nebraska Barnyard									--	.20*	.34**	.06	.15+	.25**	.24**
10. Big-Little Stroop										--	.23**	.30**	.03	.30**	.13
11. Go/No-go											--	.29**	.19*	.10	.08
12. Shape School												--	.10	.22*	.12
13. Good Shelf (reversed)													--	.41**	.37**
14. Snack Delay (movement score)														--	.74**
15. Snack Delay (ate treat; reversed)															--
16. Latent WMIC	.13	.39**	-.32**	-.10*	.09+	.14	-.10								
17. Latent self-control	.01	.02	-.23**	.08	.06	-.10	-.28**								

Note. WMIC = working memory/inhibitory control. +p < .10; *p < .05; **p < .01. Latent WMIC and self-control are correlated (r = .42, p < .01).

Table 5

Direct, indirect, and total effects of SES on executive function

Predictor	Mediator	Outcome	b	SE	95% CI
Education →	Psychological distress →	WMIC	.04	.03	[.005, .109]
Education →		WMIC	.22	.11	[.009, .414]
Total indirect effect of education →		WMIC	.04	.03	[.005, .109]
Total effect of education →		WMIC	.26	.11	[.042, .466]
ITN →	Psychological distress →	WMIC	-.01	.04	[-.118, .050]
ITN →		WMIC	.02	.18	[-.346, .376]
Total indirect effect of ITN →		WMIC	-.01	.04	[-.118, .050]
Total effect of ITN →		WMIC	.01	.18	[-.358, .366]
Education →	Psychological distress →	Self-control	.05	.02	[.013, .108]
Education →	Distress → harsh parenting →	Self-control	-.01	.01	[-.033, -.002]
Education →		Self-control	-.07	.06	[-.187, .047]
Total indirect effect of education →		Self-control	.04	.02	[.008, .092]
Total effect of education →		Self-control	-.03	.06	[-.150, .081]
ITN →	Psychological distress →	Self-control	-.01	.05	[-.112, .070]
ITN →	Distress → harsh parenting →	Self-control	.002	.01	[-.014, .032]
ITN →		Self-control	.14	.13	[-.120, .393]
Total indirect effect of ITN →		Self-control	-.01	.04	[-.093, .055]
Total effect of ITN →		Self-control	.13	.13	[-.135, .394]

Note. ITN = income-to-needs. WMIC = working memory/inhibitory control.

Figure Captions

Figure 1. Hypothesized model relating socioeconomic status to family stress (psychological distress and harsh parenting), family investment (cognitive stimulation), and executive function at 36 months.

Figure 2. Path diagram illustrating the effect of socioeconomic status (income-to-needs ratio and parental education) on working memory/inhibitory control (WMIC) and self-control. Both unstandardized and standardized (in parentheses) parameters are presented; error variances and prenatal tobacco exposure and child sex covariates are not shown. $^{*}p < .05$; $^{**}p < .01$.

Figure 3. Path diagram illustrating the effect of mediators of the relations between socioeconomic status (income-to-needs ratio and parental education), working memory/inhibitory control (WMIC), and self-control. Both unstandardized and standardized (in parentheses) parameters are presented; error variances and prenatal tobacco exposure and child sex covariates are not shown. $^{*}p < .05$; $^{**}p < .01$.

Figure 1

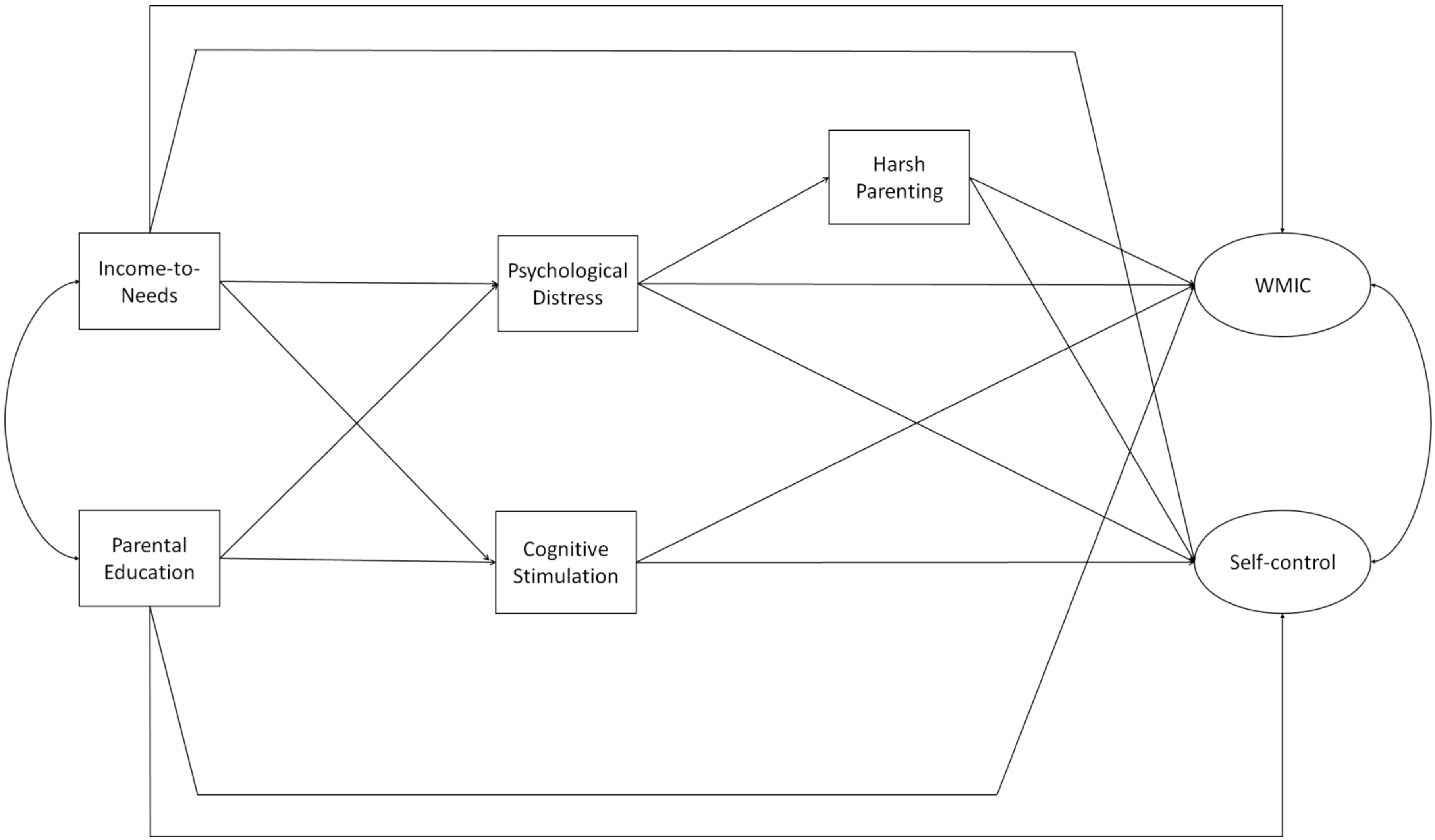

Harsh
Parenting
Income-to-
Needs
Psychological
Distress
WMIC
Parental
Education
Cognitive
Stimulation
Self-control

Figure 2

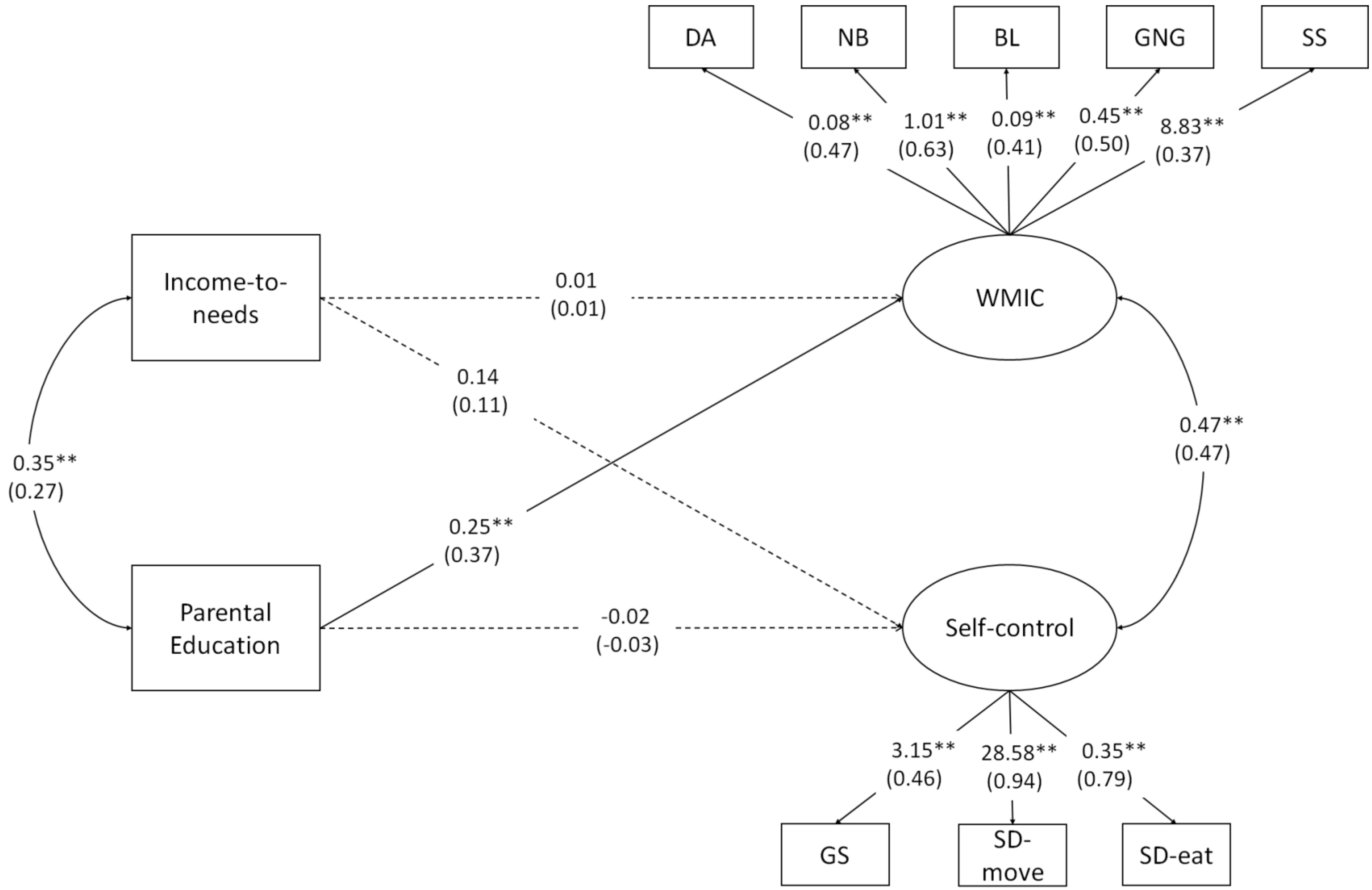
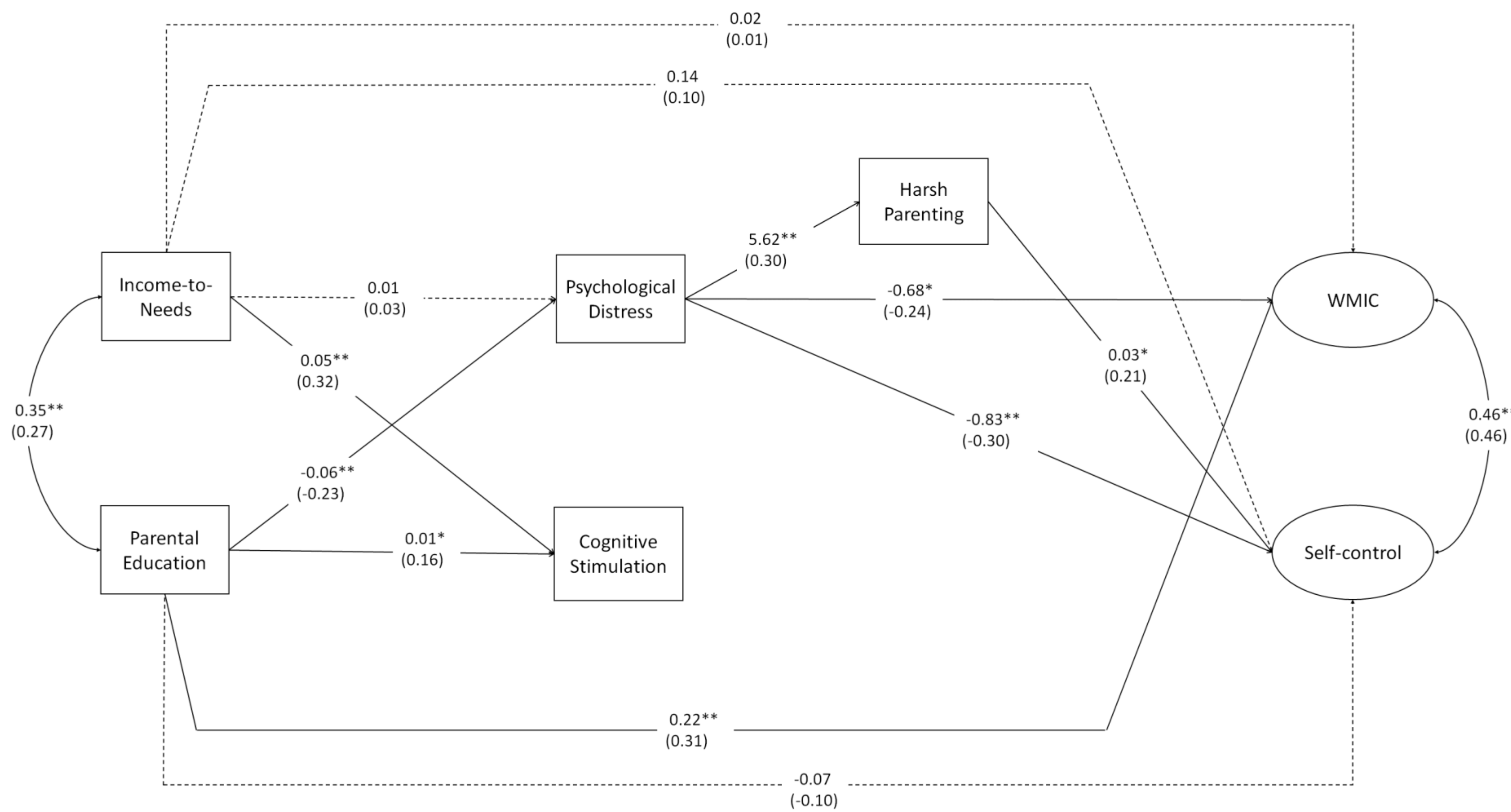

DA
NB
BL
GNG
SS
0.08**
(0.47)
1.01**
(0.63)
0.09**
(0.41)
0.45**
(0.50)
8.83**
(0.37)
Income-to-needs
0.01
(0.01)
WMIC
0.14
(0.11)
0.47**
(0.47)
0.35**
(0.27)
0.25**
(0.37)
Parental Education
-0.02
(-0.03)
Self-control
3.15**
(0.46)
28.58**
(0.94)
0.35**
(0.79)
GS
SD-move
SD-eat

Figure 3


0.02
(0.01)
0.14
(0.10)
Harsh
Parenting
5.62**
(0.30)
Income-to-
Needs
0.01
(0.03)
Psychological
Distress
-0.68*
(-0.24)
WMIC
0.05**
(0.32)
0.03*
(0.21)
0.35**
(0.27)
-0.83**
(-0.30)
0.46**
(0.46)
-0.06**
(-0.23)
Parental
Education
0.01*
(0.16)
Cognitive
Stimulation
Self-control
0.22**
(0.31)
-0.07
(-0.10)